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DRAFT FOR DISCUSSION

MEMO

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Date:
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ARCADIS Project No.:
B0064530.0000.00676

Subject:
Plainwell Bank Maintenance/Repair and Approach for Erosion at Removal Areas 8 and 9B

On June 26, 2009, a meeting was held with state and federal Trustees (Trustees) to discuss bank monitoring activities for the Plainwell Time-Critical Removal Action (TCRA) project area and to visually inspect an eroding bank area associated with Removal Areas 8 and 9B. Meeting attendees included Steve Garbaciak and Anthony Esposito of ARCADIS, Garry Griffith of Georgia-Pacific LLC, Mike Ribordy of the U.S. Environmental Protection Agency, John Lerg and Sharon Hanshue of the Michigan Department of Natural Resources, and Paul Bucholtz of the Michigan Department of Environmental Quality. This memorandum summarizes the observations made during the inspection of the eroding bank area, describes two options that were evaluated for its repair, and describes the selected repair approach that will be implemented during the 2009 construction season.

During the bank inspection event, approximately 1,000 feet (ft) of bank in Removal Areas 8 and 9B (the Study Area; Figure 1) was observed to be showing significant signs of erosion. The Study Area is located along the inside bend of a large gradual meander that was anticipated to be a depositional area following removal and revegetation activities and not subject to erosional forces requiring rock-based armoring. Figures 2 and 3 present the velocity and shear stress predicted by the RMA2 model for post-construction conditions in the Study Area during a 2-year storm event, as presented in the TCRA Design Report (ARCADIS BBL 2007). As shown, the near-bank shear stress and velocity were calculated to be 100 to 150 dynes per square centimeter (dynes/cm^2) and 2 to 4 feet per second (ft/s), respectively. Vegetated banks are capable of withstanding shear stresses of 1,500 dynes/cm^2 (American Excelsior 2009) and velocities of up to 7 ft/s (Fischenich 2001). Based on the modeled shear stress and water velocity, the

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banks in the Study Area should have been stable to these maximum tolerances if vegetation had become established before the fall 2008 flood event.

The original design for the restoration of the Study Area included a flat shelf that extended 30 ft into the river at the anticipated prism-out median flow water elevation. This shelf was to be seeded if exposed, or planted with plugs if frequently inundated. After completion of the restoration of the bank in the Study Area in late fall 2008, water levels were too high for seeding or installation of erosion control fabric; therefore, the protection and vegetation of the shelf was deferred until the following spring. During the severe storm flows that occurred in September 2008 and the winter and spring of 2009, the majority of the shelf eroded away before protective vegetation and erosion control fabric could be installed. As a result, much of the 30-ft buffer between the river and the bank experienced erosion.

According to Fischenich and Allen (2000), bank failure can result from four primary factors: hydraulic forces that remove erodible bank material, geotechnical instability, mechanical actions reducing bank strength, or a combination of these factors. Since the banks in the Study Area were restored, several storm events well over a bankfull event occurred (one approaching a 50-year storm) that likely contributed to bank erosion. During the bank inspection, the bank was observed to be cracked and blocky due to the effects of alternating periods of wet and dry conditions and freeze/thaw effects. It appeared that the geotechnical instability associated with the sloughing of these blocks and subsequent transport after entering the channel are also contributing to bank erosion.

The conditions causing erosion of the bank in the Study Area are not likely to change in the near-term unless some action is taken to stabilize the bank. The primary objective of any action is to stop the erosion of the bank and shelf to provide a buffer between the river and bank material. Three options were considered to repair and stabilize the bank in the Study Area. The first option involves the construction of several rock flow deflectors, or vanes, that deflect flow away from the bank. The second option is to armor the bank in-place at its current extent and configuration. Restoration of the eroded bank to the designed geometry by backfilling and then armoring the shelf toe was also considered; however, due to instabilities of backfill material placed in water and susceptibility of topsoil to erosion should a flood event occur shortly after placement, reliability of this approach would be relatively low and therefore it was not evaluated further.

ARCADIS evaluated each option to determine the best option to repair and stabilize the bank over the long-term. After evaluation of the pros and cons of each option, it was concluded that stabilizing the bank at its current location and configuration using rock toe protection (Option 2) provides the best balance of protection, constructability, and cost. Descriptions of each option and justification for the selected option are presented below.

Option 1: Rock Vane Option

During the bank inspection, small rock outcrops from the bank were observed creating long, downstream velocity shadows. Evaluation of the rock vane option considered the construction of rock flow deflectors along the bank to recreate this observed condition, deflecting water away from the bank and reducing the removal rate of sloughed bank material. Typically, these structures are constructed on the outer bends of meanders, where water is constantly trying to flow against the outer bank as a result of inertia. The rock vanes function to re-direct water towards the center of the channel. Structure spacing is important along an outer bank because the influence of a vane on flow direction is limited due to the constant bankward pressure of the flowing water. On the inside of a meander, flows are generally running away from the bank, so longer velocity shadows result from shorter vane lengths, in contrast to an outer bank. Design considerations for vane construction include the construction material, height, structure length, spacing, and orientation. Riprap has proven to be the best material for vane construction because its design tolerances are better known and are less susceptible to failure than other material (Fischenich and Allen 2000). The heights of vanes are designed based on channel geometry and the nature of the erosion. Although structures designed to create low-flow channels to disrupt secondary currents and protect against toe erosion are not required to be constructed at elevations much greater than the bed elevation, they are commonly constructed to the top of the bank on tight bends or where erosion occurs along the entire bank face.

The length of the structure is designed to create the desired flowline. The relationship of the length of the structure to flow deflection has been well-researched and is found to be a function of the structure length and the channel width. The spacing of vanes in convex and straight channel conditions are reported in Table 7.6 of Fischenich and Allen (2000) to range from 1 to 6.3 times the length of the vane and 0.5 to 2 times the width of the stream. Shorter spacing-to-length ratios are more applicable to outer bends, often with tighter radius of curvature. Use of these guidance values results in a designed vane length of 50 to 200 ft and a vane spacing of between 50 and 1,260 ft. To minimize disruptions to navigational and recreational uses, a vane length of 25 ft at a spacing of 100 ft was modeled using the RMA2 model to evaluate the effect on near shore velocity and shear stress in the Study Area.

Figures 2 and 3 show that the bank in the Study Area is exposed to a water velocity of 2 to 4 ft/s and shear stress of 100 to 150 dynes/cm^2 under post-construction conditions at the bankfull discharge. Model outputs with the rock vanes in place show that near-bank water velocity would be reduced to 0 to 1 ft/s and shear stress reduced to 0 to 50 dynes/cm^2 (Figures 4 and 5). The velocity and shear stress reductions are further illustrated with RMA2 model output in Figures 6 and 7.

Each rock vane would require approximately 30 cubic yards (cy) of rock to construct, including upstream (10 ft) and downstream (5 ft) bank protection. Unlike armor stone along the bank, the vane protrudes directly into the current to alter flow patterns. Therefore, the rock used to construct the vane would need to be larger than bank armor. Based upon computed shear stress, rocks used to construct the vane would need to be approximately 18 to 24 inches in diameter to be stable. The 100-ft spacing would result in 10 vanes in the Study Area, requiring a total of 300 cy of rock for all 10 structures. The structures and adjacent bank armoring would result in 27% of the bank length being hard armored.

Although the RMA2 model indicates that water velocity and shear stress would be reduced by installation of the rock vanes, this option would only address the erosion resulting from river flow and would have minimal effect on erosion caused by geotechnical instabilities. Therefore, the disadvantage of this option is uncertainty about the effectiveness of the erosion protection provided by these structures alone. In addition, the long-term stability of the vanes after experiencing several high flow events is unknown. Because the 30-ft buffer zone has already been reduced, current thinking is that it will be necessary to increase the protection factor of the bank if the bank remains in its current location. Therefore, because of the uncertainty associated with the function and stability of the vanes and the inability to effectively reduce geotechnical instability; this option was not identified as the preferred option.

Option 2: Armor In-Place Option

The option of armoring the bank in-place appears to be the best option to address bank erosion resulting from hydraulic forces and geotechnical instabilities, and to balance long-term protection with constructability and cost. The protection of the bank at its current location would provide 100% protection in an area that was thought to be adequately protected with a vegetated buffer zone. The bank repair needs to protect the bank from eroding further into undisturbed portions of the bank. The repair of the bank using this option would consist of placing river run rock from the currently observed top-of-bank shelf to the river bed at an approximate 2:1 (horizontal:vertical) slope, as shown on Figure 8. Although a 3:1 slope has been used to restore bank faces above the waterline, the 2:1 slope was selected for the protection of the shelf toe because it would be stable at the steeper slope, which would usually be under water except during drought conditions. The river run rock protection eliminates the need for the buffer zone and provides more permanent bank protection than rock vanes or vegetated banks. As shown on Figure 8, the proposed area of river run rock would extend past the limits of the Study Area to maintain the continuity of rock along the bank.

The rock placement would be similar to the bank repair performed in Removal Area 7, where rock was placed using a backhoe from the south bank. In addition to the rock toe protection, the remaining portions of the shelf behind (landward) the rock would be provided additional erosion protection by the installation of a coir log at the prism-out median water elevation, which is the interface of the rock toe protection and the shelf (Figure 8). The coir log would reduce the flood frequency enough to allow the establishment and protection of vegetation on the shelf to further stabilize the shelf. Vegetation would be established on the shelf by seeding if the bank is exposed following the repair, or plugged with hydrophytic plant species if the shelf is and/or remains inundated at median flow. Following seeding or prior to plugging, the shelf would be covered with erosion control fabric to further protect the shelf until vegetation becomes established.

It is estimated that 560 cy of river run rock would be required to stabilize the 1,000 ft of bank in the Study Area. Installation of rock would minimize turbidity concerns, relative to installation of topsoil or backfill. Turbidity could be controlled using resuspension controls around the work area. Although this option requires almost double the amount of rock required for Option 1, nearly four times the length of bank would receive long-term protection. Option 2 would also be more expensive than Option 1, but would provide long-term protection from additional erosion in bank areas that have lost some buffer area due to erosion of the shelf. The rock toe would significantly reduce the potential for future bank loss by sloughing and hydraulic erosion, and the extra protection provided by the coir log around the shelf perimeter would create conditions for the establishment of vegetation, which would provide long- term protection for the shelf.

Selected Approach

After observing conditions of the bank and river in the Study Area and evaluating options for the repair/reconstruction of the bank, it is concluded that armoring the bank from the top-of-shelf to the toe-of-bank in-place (Option 2) is the best bank repair option because it provides long-term bank protection against hydraulic erosion and geotechnical instability of the bank, facilitates the establishment of vegetation on the remaining portions of the shelf to maintain its stability, can be constructed with minimal turbidity concerns, and is of reasonable cost. Once the repair design is approved by the Trustees, the repair will be performed during this construction season (weather permitting) while equipment and materials from the Plainwell No. 2 Dam TCRA are available.

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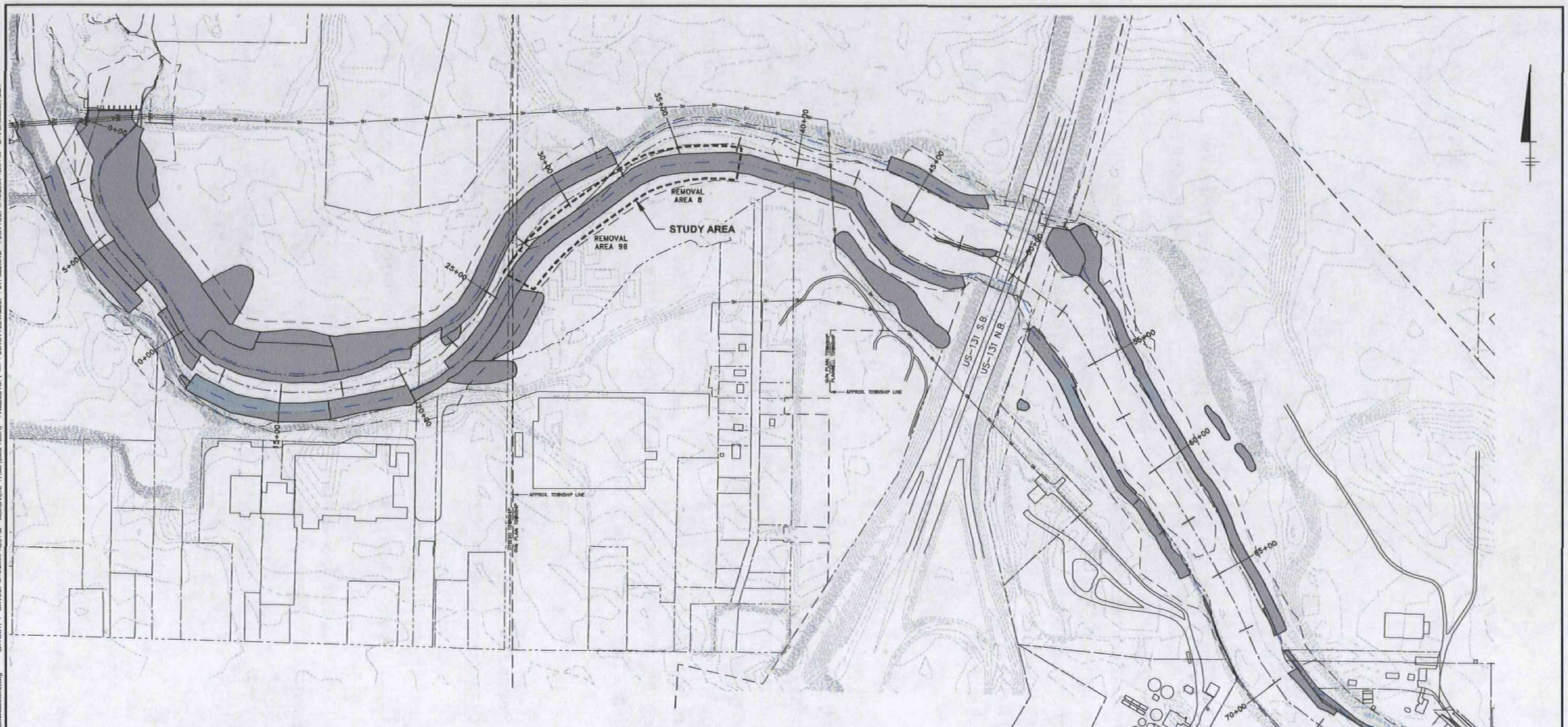
Fischenich, C. 2001. "Stability Thresholds for Stream Restoration Materials," EMRRP Technical Notes Collection (ERDC TNEMRRP- SR-29), U.S. Army Engineer Research and Development Center, Vicksburg, MS.



LEGEND:

— OH —	OVERHEAD ELECTRIC	60+00	STATION POINT (IN HUNDREDS OF FEET)
	FIBER OPTIC		KALAMAZOO RIVER CENTERLINE AND STATION LINE
	STRUCTURE		TAX PARCELS
	ELEVATION CONTOUR		APPROX. TOWNSHIP LINE
	FENCE LINE		EXCAVATION AREA
	PRE-CONSTRUCTION DAM-IN MEDIAN WATER LINE (APPROX.)		
	APPROX. LIMIT OF FIELD SURVEY		

NOTES:

1. TAX PARCELS OBTAINED FROM ALLEGAN COUNTY LAND INFORMATION SERVICES GIS DEPARTMENT AND INCLUDE OTSEGO AND GUN PLAIN TOWNSHIPS AND PLAINWELL CITY AND ARE PROJECTED IN NAD 83 STATE PLANE MICHIGAN SOUTH.
2. EXISTING FACILITIES, STRUCTURES, AND UTILITIES HAVE BEEN PLOTTED FROM AVAILABLE PLANS, RECORDS AND SURVEYS, AND, THEREFORE, THEIR LOCATIONS, MATERIALS, AND TYPE OF USE MUST BE CONSIDERED APPROXIMATE ONLY.

0 200' 400'
GRAPHIC SCALE

KALAMAZOO RIVER STUDY GROUP
ALLIED PAPER INC./PORTAGE CREEK/
KALAMAZOO RIVER SUPERFUND SITE

STUDY AREA LOCATION

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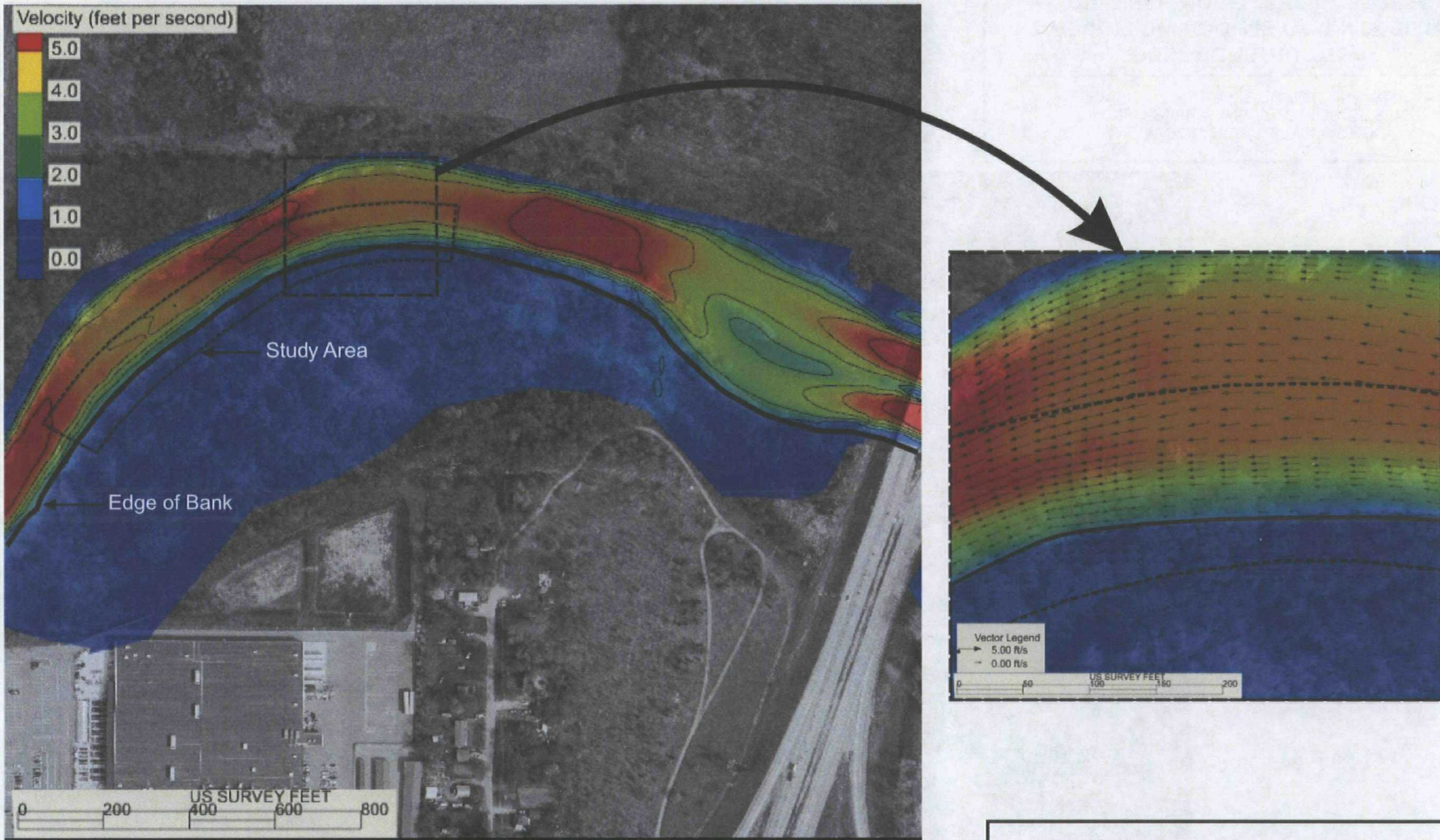
FIGURE
1

09/09/09 SYRACUSE-141ENV-DJHOWES
B0064530/0000/00675/CDR/64530G01.CDR



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POST-CONSTRUCTION
2-YEAR FLOW (Q=3,845 CFS) MODEL RUN
ORIGINAL MODEL VELOCITY

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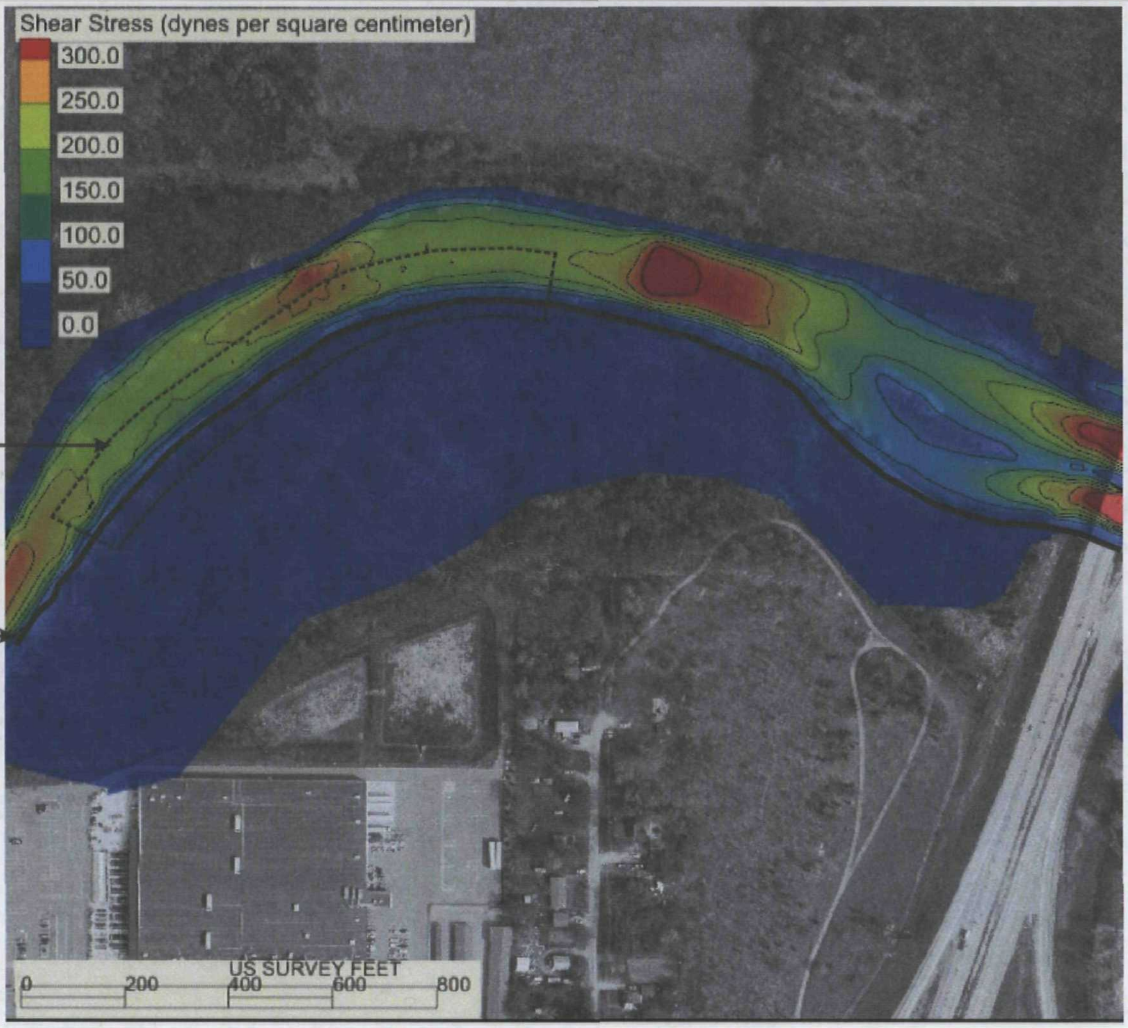
FIGURE
2

08/31/09 SYRACUSE-141ENV-DJHOWES
B0064530/0000/00675/CDR/64530G02.CDR



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POST-CONSTRUCTION
2-YEAR FLOW (Q=3,845 CFS) MODEL RUN
ORIGINAL MODEL SHEAR STRESS

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FIGURE
3

08/24/09 SYRACUSE-141ENV-DHOWES
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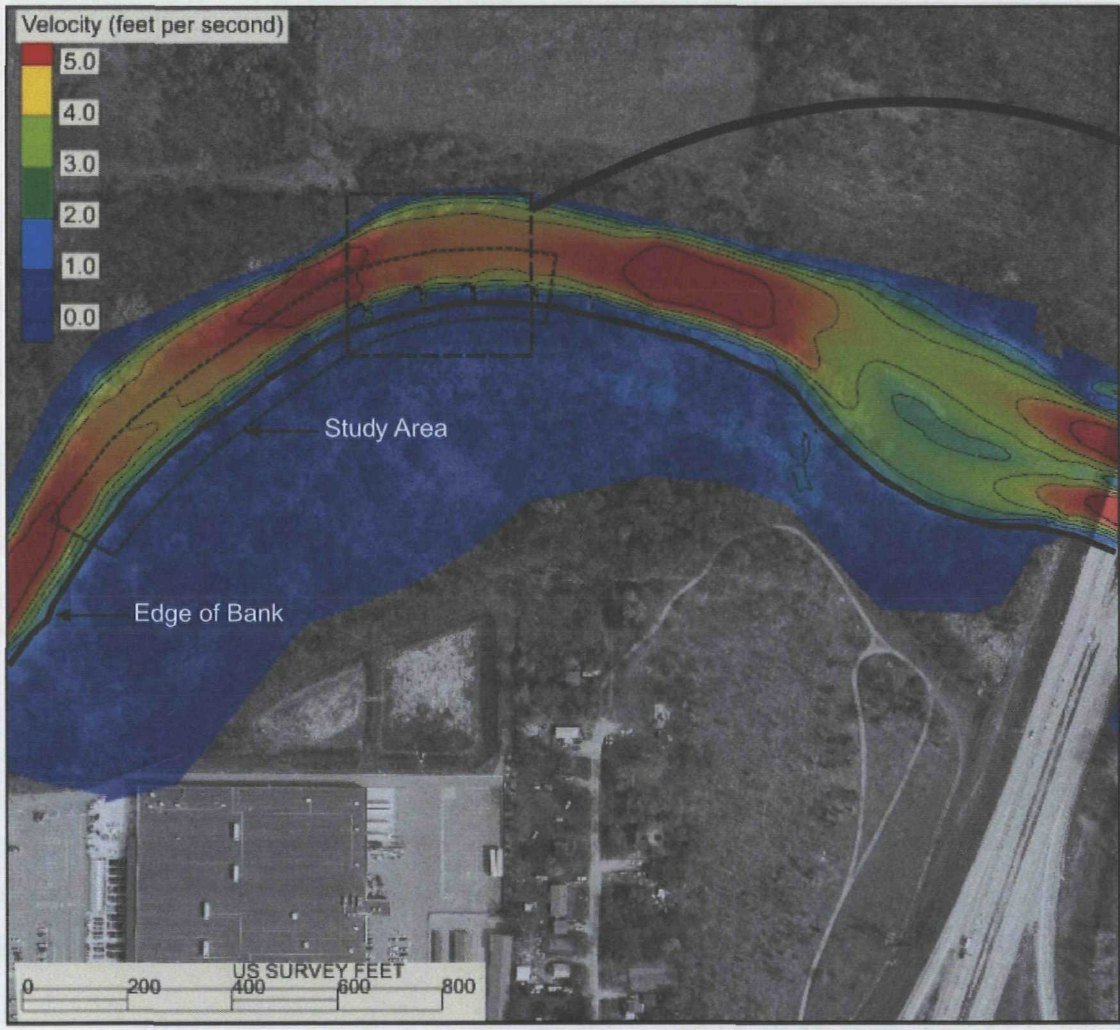

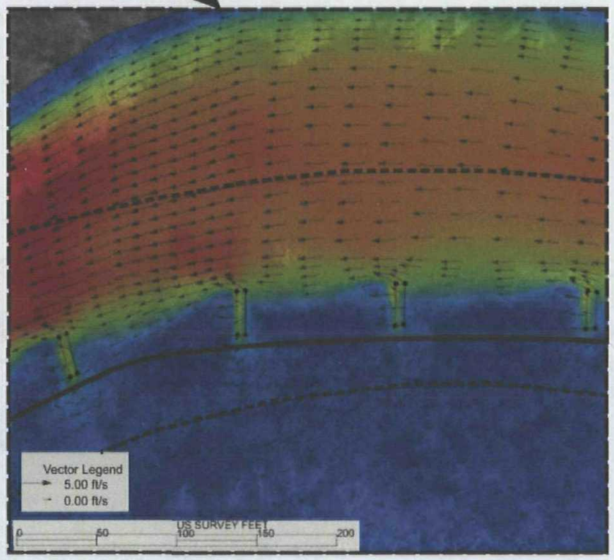

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POST-CONSTRUCTION
2-YEAR FLOW (Q=3,845 CFS) MODEL RUN
ROCK VANE MODEL VELOCITY

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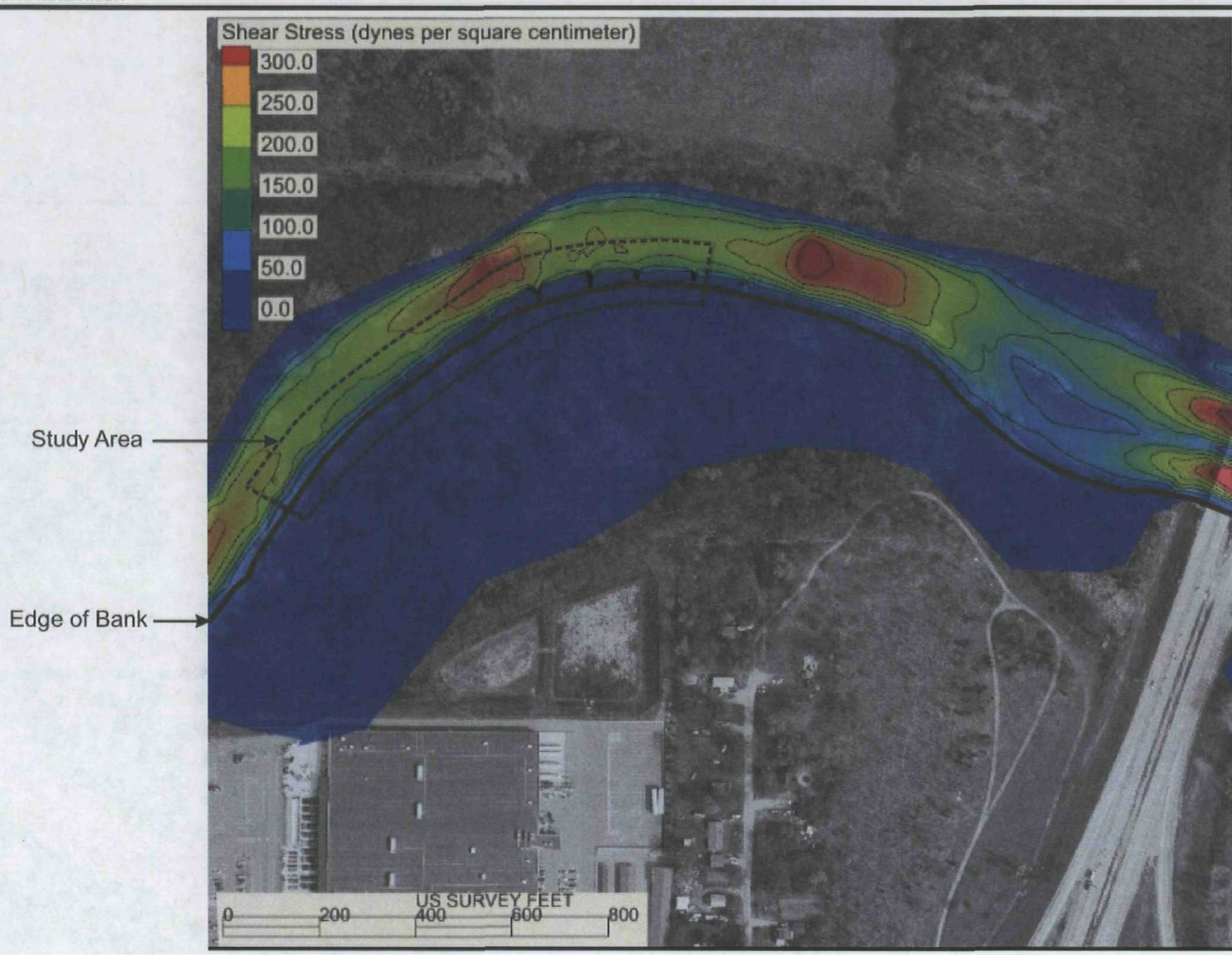
FIGURE
4



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POST-CONSTRUCTION
2-YEAR FLOW (Q=3,845 CFS) MODEL RUN
ROCK VANE MODEL SHEAR STRESS

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FIGURE
5

09/01/09 SYRACUSE-141ENV-DJHOWES
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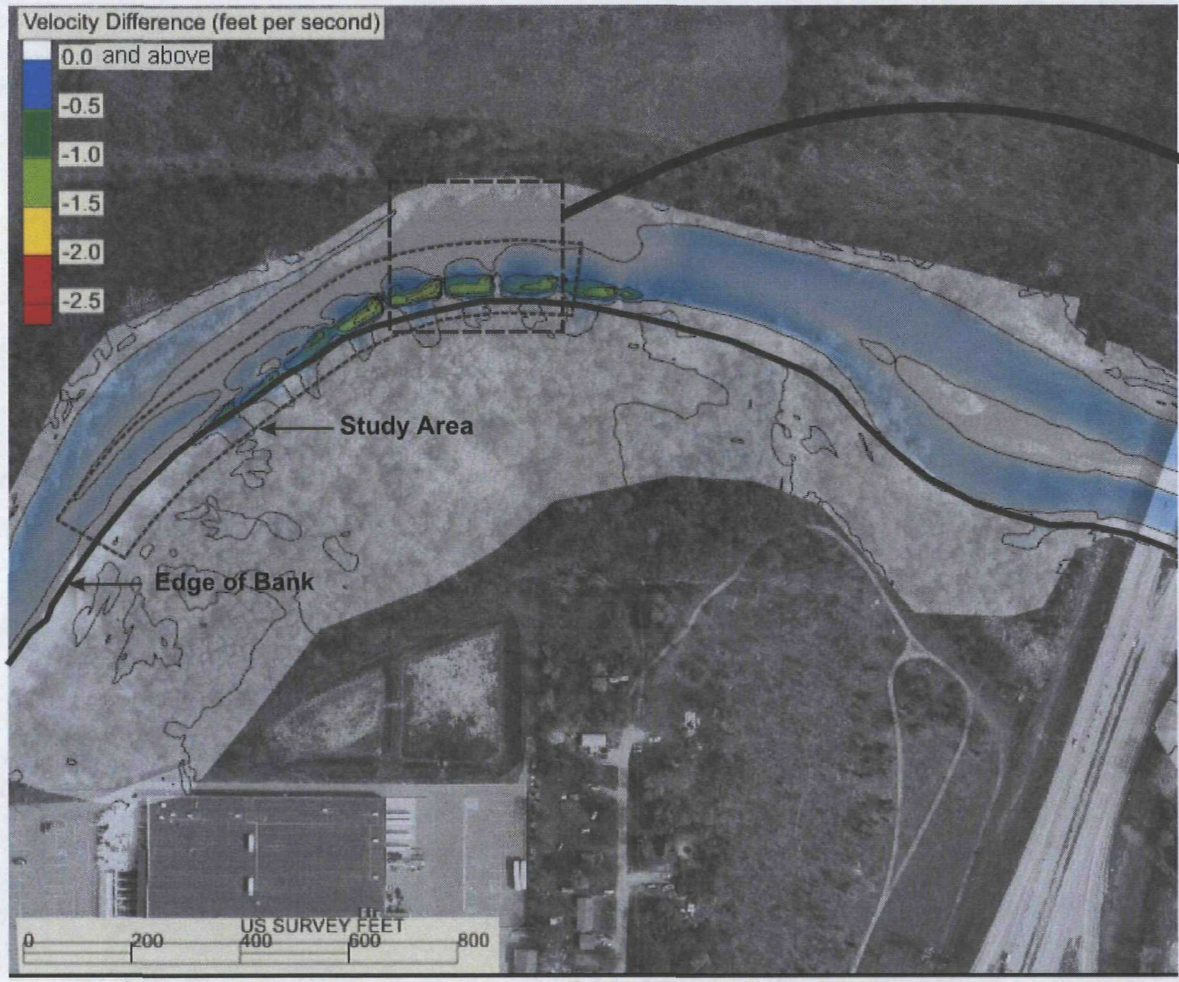

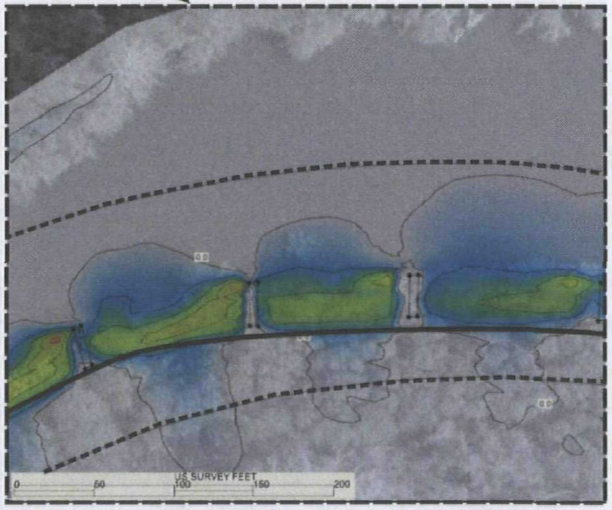

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POST-CONSTRUCTION
2-YEAR FLOW (Q=3,845 CFS) MODEL RUN
VELOCITY DIFFERENCE
(ROCK VANE MODEL VELOCITY - ORIGINAL MODEL VELOCITY)

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FIGURE
6

09/01/09 SYRACUSE-141ENV-DJHOWES
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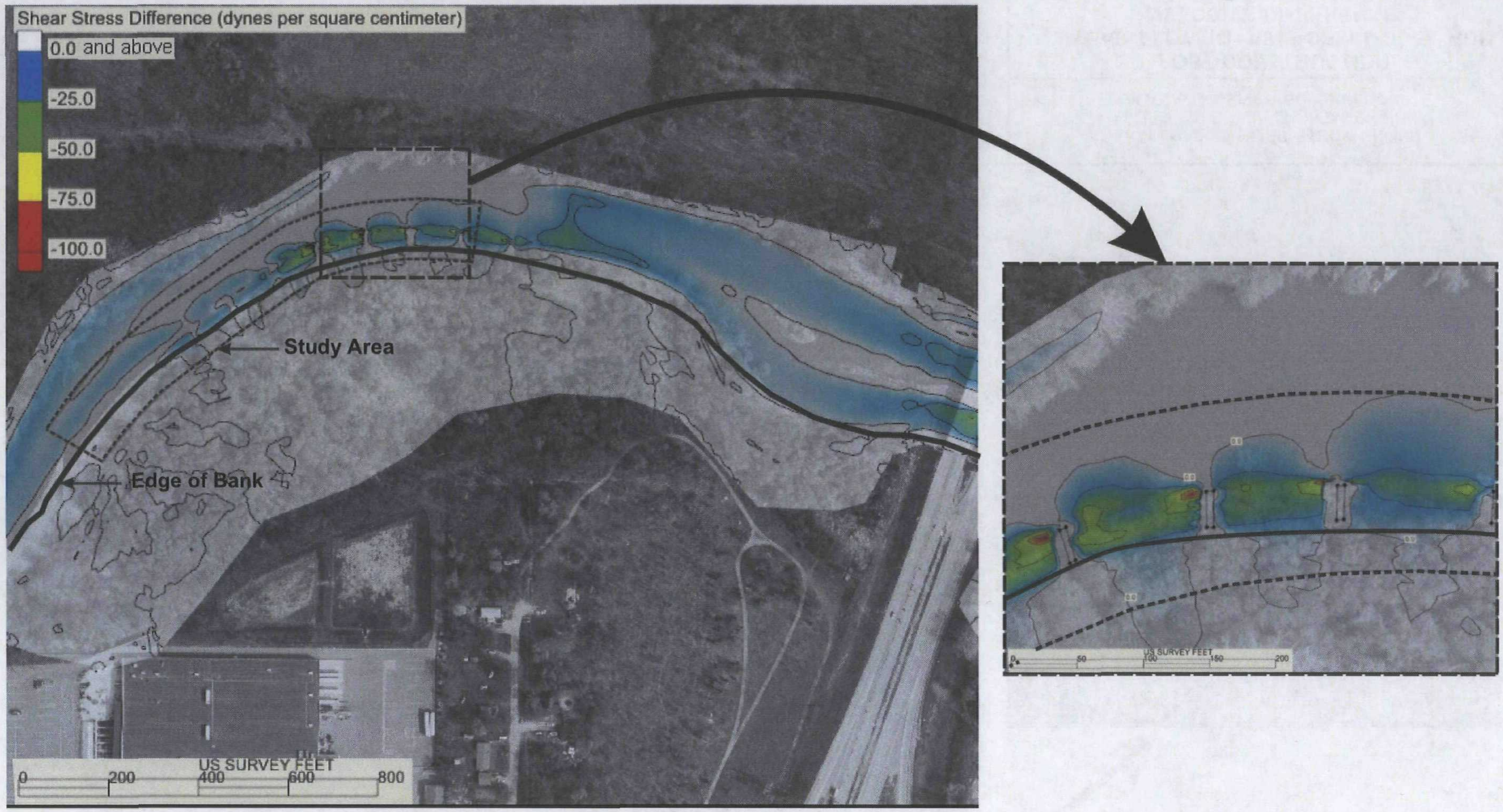

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POST-CONSTRUCTION
2-YEAR FLOW (Q=3,845 CFS) MODEL RUN SHEER STRESS DIFFERENCE
(ROCK VANE MODEL SHEAR STRESS - ORIGINAL MODEL SHEAR STRESS)

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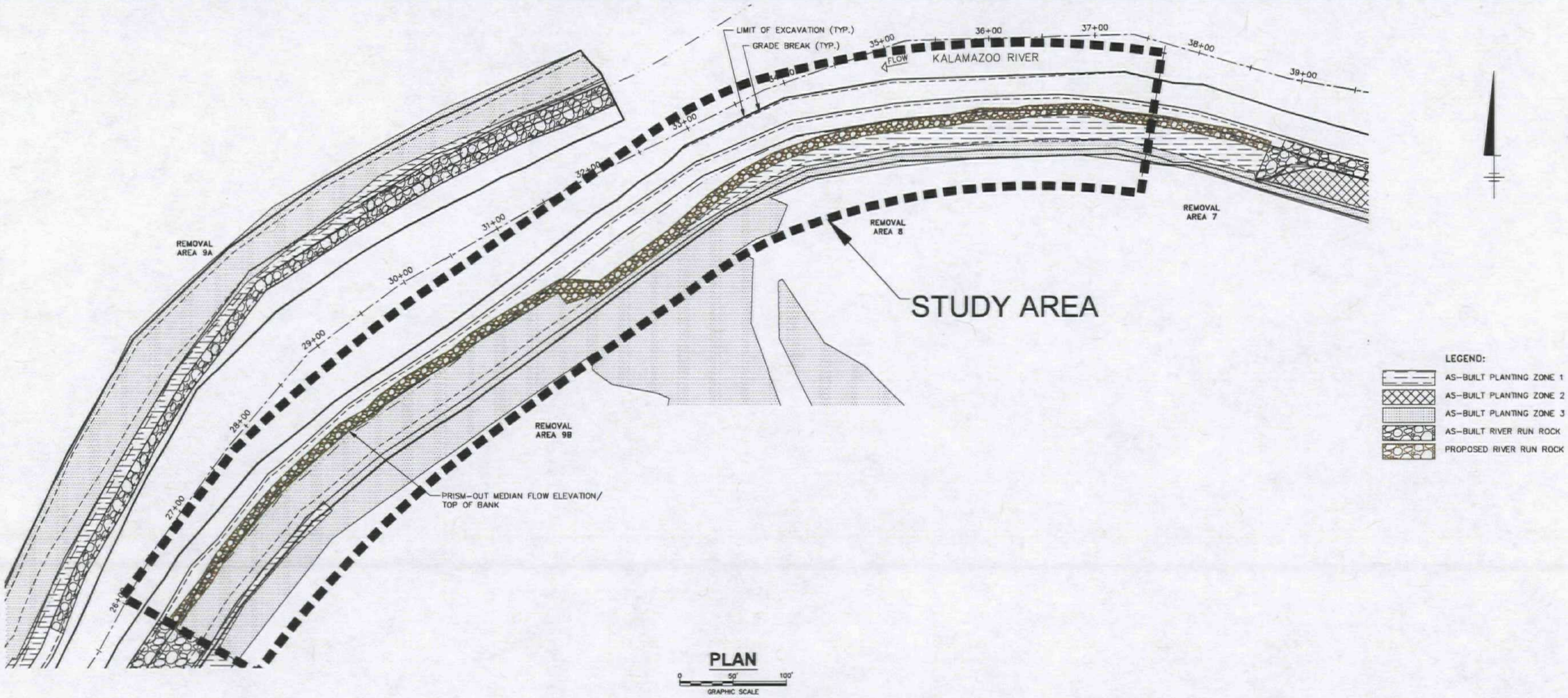
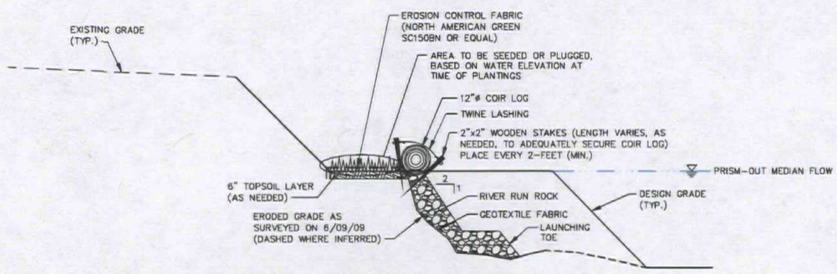
FIGURE
7



PLAN



TYPICAL RESTORATION CROSS SECTION
SOUTH BANK
NOT TO SCALE
(3X VERTICAL EXAGGERATION)

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PROPOSED BANK EROSION REPAIR PLAN AND CROSS SECTION

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FIGURE
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